

Customer No.	026418	
Attorney's Docket No.:	GK-GEY-1112 / 500353.20135	
U.S. Application No.:		
International Application No.:	PCT/EP00/08090	
International Filing Date:	AUGUST 18, 2000	18 AUGUST 2000
Priority Date Claimed:	AUGUST 25, 1999	25 AUGUST 1999
Title of Invention:	METHOD FOR PRODUCING A LIGHT INTEGRATOR, A LIGHT INTEGRATOR, AND A USE THEREOF	
Applicant(s) for (DO/EO/US):	Peter DANNENBERG and Bernhard WAGNER	

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

- [X] 1. This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.  
[ ] 2. This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.  
[ ] 3. This express request to begin national examination procedures [35 U.S.C. 371 (f)] at any time rather than delay examination until the expiration of the applicable time limit set forth in 35 U.S.C. 371(b) and PCT Articles 22 and  
[ ] 4. A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.  
[X] 5. A copy of the International Application as filed [35 U.S.C. 371(c)(2)]  
a) ☐ is transmitted herewith (required only if not transmitted by the International Bureau)  
b) ☐ has been transmitted by the international Bureau  
c) ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)  
[X] 6. A translation of the International Application into English [35 U.S.C. 371(c)(2)]  
[ ] 7. Amendments to the claims of the International Application under PCT Article 19 [35 U.S.C. 371(c)(3)]  
a) ☐ are transmitted herewith (required only if not transmitted by the International Bureau)  
b) ☐ have been transmitted by the International Bureau  
c) ☐ have not been made; however, the time limit for making such amendments has **NOT** expired.  
d) ☐ have not been made and will not be made  
[ ] 8. A translation of the amendments to the claims under PCT Article 19 [35 U.S.C. 371(c)(3)]  
[X] 9. An UNSIGNED Oath or declaration of the inventor(s) [35 U.S.C. 371(c)(4)] Executed Decl/POA TO FOLLOW  
[ ] 10. A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 [35 U.S.C. 371(c)(5)]

**Items 11. to 16. Below concern other document(s) or information included:**

- [X] 11. An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98  
[ ] 12. An Assignment document for recording. A separate cover sheet (PTO-1619A) in compliance with 37 CFR 3.28 and 3.31 is included.  
[X] 13. ☐ A **FIRST** preliminary amendment  
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment  
[X] 14. A **substitute specification**  
[ ] 15. A change of power of attorney and/or address letter  
[X] 16. (other items or information) **PCT/RO/101, PCT/IB/301 and PCT/IB/304 dated 19OCT00, PCT/IB/308 and 1<sup>st</sup> page of WO 01/14923 dated 01MAR01, Search Report (PCT/ISA/210 and PCT/ISA/210) 25JAN00 and PTO-1449 w/7 references (including 3 English Abstract)**

EXPRESS MAIL No.: **EL 758 525 142 US**

Deposited: **April 25, 2001**

I hereby certify that this correspondence is being deposited with the United States Postal Service Express mail under 37 CFR 1.10 on the date indicated above and is addressed to: BOX PCT, Commissioner for Patents, Washington, DC 20231.

  
/Ruth Montalvo Date: **April 25, 2001**

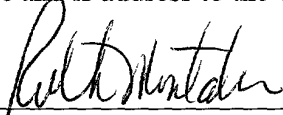
<b>[X] 17. The following fees are submitted:</b> BASIC NATIONAL FEE [37 CFR 1.492(a)(1)-(5)]						
<b>[X]</b>	Search Report has been prepared by the EPO or JPO.....	\$	860.00			
<b>[ ]</b>	International preliminary examination fee paid to USPTO [37 CFR 1.482].....	\$	690.00			
<b>[ ]</b>	No International preliminary examination fee paid to USPTO [37 CFR 1.482] but International search fee paid to USPTO [37 CFR 1.445(a)(2)].....	\$	710.00			
<b>[ ]</b>	Neither International preliminary examination fee [37 CFR 1.482] nor International search fee [37 CFR 1.445(a)(2)] paid to USPTO.....	\$	1,000.00			
<b>[ ]</b>	International preliminary examination fee paid to USPTO [37 CFR 1.482] and all claims satisfied provisions of PCT Article 33(1)-(4).....	\$	100.00			
<b>ENTER APPROPRIATE BASIC FEE AMOUNT:</b>					<b>\$860.00</b>	
Claims		Number Filed		Number Extra	Rate	
Total Claims Prel. Amdt)		12	-20		x \$ 18. =	
Indep. Claims		2	-03		x \$ 80. =	
<b>[ ]</b> Multiple Dependent Claim(s) (if applicable)					+ \$ 270. =	
<b>TOTAL OF ABOVE CALCULATIONS:</b>					<b>\$860.00</b>	
Surcharge of \$130.00 for furnishing the oath or declaration later than <b>[ ]</b> 20 <b>[ ]</b> 30 months from the earliest claimed priority date [37 CFR 1.492(e)]						
<b>TOTAL OF ABOVE CALCULATIONS:</b>					<b>\$860.00</b>	
Applicant claims Small Entity Status [See 37 CFR 1.27] Reduction by 1/2 for filing by small entity						
<b>SUBTOTAL:</b>					<b>\$860.00</b>	
Processing fee of \$130.00 for furnishing the English Translation later than <b>[ ]</b> 20 <b>[ ]</b> 30 months from the earliest claimed priority date [37 CFR 1.492(f)]						
<b>TOTAL NATIONAL FEE:</b>					<b>\$860.00</b>	
Fee for recording the enclosed assignment [37 CFR 1.21(h)] The assignment must be accompanied by an appropriate cover sheet (PTO-1595) [37 CFR 3.28, 3.31]. \$ 40.00 per property +						
<b>TOTAL FEE(S):</b>					<b>\$860.00</b>	
AMOUNTS TO BE REFUNDED OR CHARGED					<b>REFUNDED</b>	<b>\$</b>
					<b>CHARGED</b>	<b>\$</b>
(Please note the filing fee is based on the claims in the Preliminary Amendment)						
<b>[X]</b> Check in the amount of <b>\$ 860.00</b> to cover the above fees is enclosed. (The Commissioner is hereby authorized to charge any additional fees required with this submission or to credit any overpayment to Deposit Account No: 50-1529.)						
<b>NOTE:</b> Where an appropriate time limit under 36 CFR 1.494 or 1.495 has not been met, a petition to revive [37 CFR 1.137(a) or (b)] must be filed and granted to restore the application to pending status.						
<b>SEND ALL CORRESPONDENCE TO:</b>						
Gerald h. Kiel, Esq. (Customer No. 026418) Reed Smith LLP 375 Park Avenue New York, NY 10152						
Gerald H. Kiel		Signature		25,116	April 25, 2001	
Name (Tel. (212) 521-5400)				Reg. No.	Date	

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JC03 Rec'd PCT/PTO 25 APR 2001

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Ruth Montalvo

  
Date

Docket No.: GK-GEY-1112/500350.20135

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

Applicant: Peter DANNENBERG and Bernhard WAGNER  
Serial No.: Unknown (Int'l Appln. PCT/EP00/08090  
filed August 18, 2000)  
Filed: Simultaneously Herewith  
For: METHOD FOR PRODUCING A LIGHT INTEGRATOR, A LIGHT  
INTEGRATOR, AND A USE THEREOF

**PRELIMINARY AMENDMENT**

Commissioner for Patents  
Washington, D.C. 20231

Sir:

Please amend the above-identified application, filed simultaneously herewith,  
as follows:

**IN THE SPECIFICATION**

Cancel the present specification and substitute therefor the enclosed substitute  
specification.

## IN THE CLAIMS

Page 12, line 1, change "Claims" to –What is claimed is--.

Cancel claims 1-11 and add new claims 12-22, reading as follows:

12. (new) A method for producing a light integrator, comprising the following steps for forming a cavity of the integrator having an inner reflective coating:  
fabricating at least two parts from which the light integrator can be assembled and whose surfaces, provided as inner sides of the cavity, are exposed;  
providing rimless reflective coating of at least the surfaces of the parts as inner sides of the cavity; and  
assembling and fastening of the parts.

13. (new) The method for producing a light integrator according to claim 12, wherein fastening is carried out by the following steps:  
covering the assembled parts with shrink tubing;  
shrinking the tubing until a suitable strength of the cavity integrator is achieved.

14. (new) A light integrator for homogenization of a light bundle entering an input surface and exiting from an output surface, comprising that:  
said light integrator has a cavity with an inner reflective coating for conducting light; and  
said light integrator being composed of at least two parts whose surfaces, which are exposed prior to assembly and face inward after assembly, are provided with a mirror layer.

15. (new) The light integrator according to claim 14, wherein one part is provided with a projection engaging in a cutout of the other part after assembly.

16. (new) The light integrator according to claim 15, wherein the inner sides and outer sides of the light integrator which form the cavity are planar, the light integrator has the shape of a geometric prism with rectangular bottom and top surfaces

provided as outlet and inlet surfaces, and the projection and cutout are rectangular, particularly square.

17. (new) The light integrator according to claim 16, wherein the light integrator comprises two T-shaped and two I-shaped side parts.

18. (new) The light integrator according to claim 14, wherein the parts are held together by at least one piece of shrink tubing.

19. (new) The light integrator according to claim 18, wherein shrink tubing is arranged in the middle between the input surface and output surface for holding the parts together.

20. (new) The light integrator according to claim 18, wherein it has two pieces of shrink tubing enclosing the light integrator for holding the parts together in the vicinity of their input surface and output surface.

21. (new) A method of using the light integrator according to claim 14, including the step of homogenizing the light originating from a light source which is provided for the illumination of an electronically controllable matrix for showing image elements.

22. (new) The method according to claim 21, wherein the matrix is a tilting mirror matrix.--

#### **IN THE ABSTRACT OF THE DISCLOSURE**

Cancel the present Abstract of the Disclosure and substitute therefor the enclosed Abstract of the Disclosure.

#### **REMARKS**

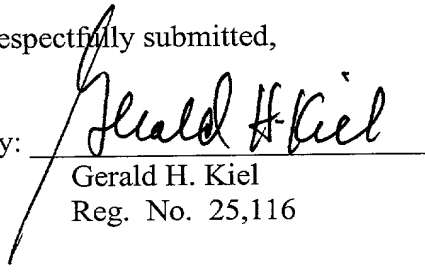
Claims 1-11 have been cancelled and new claims 12-22 have been added.  
The amendments to the claims have been made only to improve the form of the claims for examination purposes.

The specification and abstract have been amended to conform it to U.S. format.

An early and favorable action on the merits is respectfully requested.

Respectfully submitted,

By:

  
Gerald H. Kiel  
Reg. No. 25,116

April 17, 2001  
REED SMITH LLP  
375 Park Avenue  
New York, NY 10152-1799  
GHK:jl  
Enc.: Substitute Specification  
Abstract of the Disclosure

## ABSTRACT OF THE DISCLOSURE

A method for producing a light integrator for forming a cavity of the integrator having an inner reflective coating is comprising the following steps of fabricating at least two parts from which the light integrator can be assembled and whose surfaces, provided as inner sides of the cavity, are exposed, providing rimless reflective coating of at least the surfaces of the parts as inner sides of the cavity, assembling and fastening of the parts.

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JC03 Rec'd PCT/PTO 25 APR 2001

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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Applicant(s) for (DO/EO/US):	Peter DANNENBERG and Bernhard WAGNER	

SUBSTITUTE  
SPECIFICATION



Docket No.: GK-GEY-1112/500350.20135

METHOD FOR PRODUCING A LIGHT INTEGRATOR, A LIGHT  
INTEGRATOR, AND A USE THEREOF

5

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority of German Application  
No. 199 40 305.8, filed August 25, 1999 and International Application No.  
PCT/EP00/08090, filed August 18, 2000, the complete disclosure of which is hereby  
10 incorporated by reference.

BACKGROUND OF THE INVENTION

a) Field of the Invention

15

The invention is directed to a method for producing a light integrator  
and to a light integrator for homogenizing a light bundle entering an input surface  
and exiting from an output surface. The invention is further directed to a use of this  
method.

b) Description of the Related Art

20

Light integrators are known. In principle, they comprise a body  
which is coated uniformly by reflecting material in which the light is introduced, the  
light is then repeatedly reflected back and forth at the reflecting surfaces. Because  
of the multiple reflection, the origin of the light for the light bundles exiting at the  
25 output is lost to a great extent. In this way, a homogenized illumination surface is  
achieved.

Integrators are used wherever especially uniform illumination is  
desired, for example, in imaging technology where every image component to be  
imaged should receive the same amount of light.

30

EP 0 734 183 A2 proposes a light tunnel which is inserted between  
illumination optics and an LCD matrix to be illuminated. This light tunnel, as it is  
called, is an elongated rectangular parallelepiped, for example, whose opposing

surfaces on either side of a longitudinal axis determining the principal propagation direction of the light are utilized as light inlet and light outlet surfaces. The other surfaces at right angles to the principal propagation direction of the light are used as mirror surfaces.

5                   Further, it is indicated in this reference that total reflection can also be utilized in that this rectangular parallelepiped is produced in a simple manner from one piece of smooth polished glass and the angles for coupling in are selected such that the reflection is carried out at the sides by total reflection.

10                   Total reflection is extremely advantageous for these purposes because few losses need be taken into account. The only losses occurring in such light integrators in theory are caused by the absorption of the material; but this absorption can be suppressed to a very great extent when a glass of corresponding purity is used for producing an integrator of this kind.

15                   However, holding a light tunnel or mixing rod of this kind presents difficulties. Every contact with the outside surface reduces and interferes with total reflection, so that there is a risk of corresponding losses due to scattering.

20                   The principle of image generation such as it is presented in the European Patent, for example, is based on the light beams which are parallelized again after the light tunnel being directed to at least one LCD matrix. For image generation, the LCD matrix is controlled, for example, with a control device for showing video images. In principle, a video image could be projected into a screen as a large image with the technique known from slide projection or, as with the episcopes, could project the reflected light with LCD matrices with reverse reflective coating.

25                   This large-image technique is looked upon as promising in terms of future developments because electronic picture tube technology cannot be used with very large images.

30                   When using the reflected light projection method, a mirror matrix can be provided for image generation instead of the LCD matrix. A matrix of this kind is available, e.g., as a circuit, from Texas Instruments. In this circuit, a plurality of tilting mirrors, one for each image point, which are arranged in the form of a matrix

is digitally controlled. In one of the digital states, every tilting mirror reflects the full light intensity; in the other state, the mirror receives and reflects the light at an angle at which it can no longer be projected onto the screen, i.e., the corresponding image point on the screen is dark with the exception of small proportions of scattered light.

The different brightness for showing a gray value or color value of a picture point can be brought about in that the mirrors are acted upon by pulse trains, so that only an intermediate value between the full light intensity and dark is detected in the eye of the observer for every image point averaged over time.

However, the large-projection method mentioned above imposes very strict requirements on the light integrator. That is, large light losses cannot be permitted in large-image projection if there is to be a sufficient quantity of light for an image projected onto a screen. As has already been made clear, only total reflection is suitable for this purpose, in principle; however, the support of a mixing rod presents difficulties because it can lead to excessive light losses. Further, the light inlet surface and outlet surface are exposed to a high energy flow of light and can accordingly change color. Further, dust on the inlet surface and/or outlet surface inevitably reduces the light flow in an uncontrolled manner. Because of these disadvantages, it would be extremely desirable to use other light integrators.

In order to prevent interference of reflection, as in total reflection, it is conceivable that all outer surfaces could be provided with a reflective coating in the rectangular parallelepiped-shaped rod mentioned above. However, this would result in the further disadvantage of cumulative light losses from the material and mirror.

In order to eliminate losses caused by material at least, it would be possible to guide the light inside a cavity with internal reflective coating. However, this idea can hardly be realized in optimal manner in practice because, as every person skilled in the art knows, a uniform internal reflective coating with sufficient mirror quality for minimizing losses cannot be realized in practice.

## OBJECT AND SUMMARY OF THE INVENTION

It is the primary object of the invention to provide an integrator which is optimized with respect to the amount of light that is transmitted, but which does not have the disadvantages of a totally reflecting rod.

5           This object is met by a method for producing a light integrator which has the following steps for forming a cavity of the integrator having an inner reflective coating:

            fabrication of at least two parts from which the light integrator can be assembled and whose surfaces, provided as inner sides of the cavity, are exposed;

10           rimless reflective coating of at least the surfaces of the parts which are provided as inner sides of the cavity;

            assembly and fastening of the parts.

            This results in a light integrator according to the invention for homogenization of a light bundle entering an input surface and exiting from an  
15           output surface, characterized in that it has a cavity with an inner reflective coating for conducting light, wherein the light integrator is composed of at least two parts whose surfaces which are exposed prior to assembly and face inward after assembly are provided with a reflective or mirror layer.

            Accordingly, of the alternatives discussed above, the cavity with  
20           internal reflective coating is preferable. As was already explained above, this alternative would not have been reasonable at all and would not even have been considered by the person skilled in the art because an inner reflective coating with a permissibly low degree of losses would not have been possible at all. Prior to the invention, the only recourse would have been to provide a silver coating in the  
25           interior by vacuum deposition, for example; but this oxidizes easily when it is not provided with a protective layer. This protective layer would also cause absorption again.

            In particular, it can easily be calculated that with a reflection factor of 96% and 5 reflections, 20% of the light in the integrator would be lost; and it is  
30           questionable whether such a high reflection factor could even be achieved. It is only by taking apart the cavity, according to the invention, that is, dividing the integrator

into at least two parts, wherein the inner sides of the cavity are exposed with respect to the reflective coating, that it is possible to produce highly reflecting layers with a reflection factor of 98%, for example, by applying dielectric layers to the metal coating. With a reflection factor of 98%, which is certainly attainable in this way, a transmission of greater than 90% is provided with 5 reflections; that is, a loss of only 10% need be taken into account.

Further, it is possible to apply an essentially dielectric mirror possibly with a thin metal layer beneath it as back coat so as to further reduce losses.

The light propagates essentially in air in a cavity integrator, so that the losses are determined solely by the mirror layers and optionally low, permissible losses in the integrator can be achieved in accordance with expenditure. However, the assembly of the parts could cause additional losses, for example, due to glue at the glue joints. In particular, care should be taken that no glue accidentally falls on the mirror layers because this would result in proportionately high waste. Fastening the parts to one another with glue or by screw connection would also be time-consuming, which would add unnecessarily to the cost of producing an integrator of this kind if another possibility were not found.

According to a further development of the invention which is preferred in this respect, it is provided that the step for fastening is carried out by means of the following sub-steps:

covering the assembled parts with shrink tubing;  
shrinking the tubing until a suitable strength of the cavity integrator is achieved.

In this way, a light integrator according to the further development is characterized in that the parts are held together by means of at least one piece of shrink tubing.

The method of providing parts with shrink tubing is known from electrical engineering, wherein a piece of tubing which is larger than the location to be insulated, for example, a solder joint, is placed over the latter for fast insulation. By applying heat, for example, hot air, the tubing shrinks and completely encloses the solder joint, for example.

This method was previously provided exclusively for insulation and has proven to be a fast procedure for this purpose. It is used herein for the first time for fastening purposes.

This type of fastening is characterized by simple and fast handling.

5 But also, due to the elasticity of the shrink tubing, the pressure is automatically distributed on the joined parts, which are preferably made from glass, and breakage or other damage to parts is prevented.

10 Further, due to its elastic tensioning, the shrink tubing ensures that the parts to be fastened are pressed very close together. With polishing grades commonly used in optics, this means that the parts can contact one another so as to be practically light-proof. Accordingly, there is only a slight chance that the light within the cavity could reach the area between contacting surfaces of the parts from which the light integrator is composed where it would no longer be available for illumination. This result could only be achieved in small measure with a glue and  
15 would also not be reproducible because the spacing of the parts would then be determined essentially by the amount of glue.

When production is carried out using glass and glue, positional tolerances of the opening of only +0.2 mm can be achieved, whereas positional tolerances of less than 0.05 mm can be realized when fastening with plastic.

20 With respect to the fastening of the shrink tubing, two main alternatives are preferred:

1. Fastening by holding the parts together by means of shrink tubing arranged in the middle between the input surface and output surface;
2. Fastening by holding together the parts in the vicinity of their  
25 input surface and output surface by two pieces of shrink tubing enclosing the integrator.

The following further developments have to do essentially with the shaping of the parts in order to provide the most favorable possible integrator with respect to manufacture, economy and reproducibility. Preferred further  
30 developments of this kind are characterized in that:

one part is provided with a projection engaging in a cutout of the other part after assembly;

the inner sides and outer sides of the light integrator which form the cavity are planar, the light integrator has the shape of a geometric prism with rectangular bottom and top surfaces provided as outlet and inlet surfaces, and the projection and cutout are rectangular, particularly square;

the light integrator is composed of two T-shaped and two I-shaped side parts.

Above all, the projection in the cutout not only provides for a reproducible assembly, but also reduces a possible gap in which light could be lost, wherein the residual gap can be kept very small by means of pressing, for example, by means of the shrink tubing mentioned above.

The above-mentioned shaping with rectangular projection and cutout simplifies manufacture above all. In particular, the assembly of two T-shaped side parts and two I-shaped side parts simplifies the arrangement of the mirror layers. Further, there are only two sorts of parts, namely, T-shaped and I-shaped, which can then be produced in a simple manner by mass production. The embodiment examples shown in the following once again illustrate the most advantageous shaping of the individual parts.

Because of the low light loss, the use of such integrators for homogenization of the light coming from a light source provided for the illumination of an electronically controllable matrix for showing image elements is extremely advantageous. While the illumination of LCD matrices is already known from the prior art, it is also provided according to the invention that the matrix is a tilting mirror matrix when used in this way.

Further particulars of the invention are indicated in the following description of embodiment examples with reference to the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Fig. 1 is a schematic view illustrating the manner of operation of a light integrator using the example of projection with a matrix, particularly a tilting mirror matrix;

Fig. 2 shows a perspective view of an integrator according to the invention;

Fig. 3 shows a front view of the integrator of Fig. 2; and

Fig. 4 shows another embodiment example for an integrator according to the invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

The use of an integrator 2 for illuminating an LCD matrix or DMD matrix, referred to hereinafter as tilting mirror matrix, is illustrated schematically in Fig. 1. Its application is not restricted to matrices of this type for electronic image display; however, it is extremely advantageous to use an integrator of this type for illumination of such matrices, particularly because a tilting mirror matrix 4 has very small dimensions of less than 1mm\*1mm, a surface which cannot be illuminated uniformly when focusing with high luminous densities alone because the light spot usually has the same dimensions when focusing the light of a lamp with high luminous density.

The entire arrangement shown in Fig. 1 is arranged on one optical axis 6. This is also not limiting. An arrangement, e.g., optics, whose optical axes are offset relative to one another can also be put together.

A light beam 8, shown by way of example, which can be generated by means of a lamp provided with a parabolic mirror, is introduced into the input surface 12 of the integrator 2 through in-coupling optics 10. The light beam 8 is reflected back and forth repeatedly inside the integrator 2 which has a reflective coating on the inner side of the side parts 14 or when the integrator 2 comprises a medium with a suitable index of refraction for total reflection. This results in a pseudostochastic distribution of the entering light beams 8 in the light outlet surface 16.



Because of the pseudostochastic distribution, the light beam 8 is highly homogenized at the output of the integrator. It can be parallelized again by out-coupling optics 18 as is shown schematically in Fig. 1. The light bundle which is homogenized in this way is then directed onto the tilting mirror matrix 4 from which it is subsequently directed into projection optics which project the image that is generated electronically by the tilting mirrors of the tilting mirror matrix 4 onto a screen, thereby making it visible to the observer.

Fig. 2 shows an integrator 2, according to the invention, which is advantageous particularly for application with a tilting mirror matrix 4. The integrator 2 is a cavity integrator which has a reflective coating on the inner sides of the side parts 14, 14'. A cavity integrator is characterized above all by the fact that the inlet surface 12 and the outlet surface 16 are not thermally loaded, so that no changes in color occur with high light output and no dust particles can collect. An integrator 2 which is constructed as a cavity integrator is particularly advantageous when using small tilting mirror matrices because especially high luminous densities are used in this case.

In order to provide the cavity integrator with internal reflective coating in a simple manner, the cavity integrator is composed of four parts, two T-shaped parts 14' and two I-shaped parts 14. The arrangement and shape of the parts can also be seen particularly from Fig. 3. The T-shaped parts and I-shaped parts are shaped and pressed together in such a way that they do not allow any shearing movement relative to one another. The parts could also be shaped differently and put together with a cutout in the manner of tongue-in-groove so that an exact right-angled geometry is always ensured. However, due to the I-shaped parts 14 and the T-shaped parts 14' in which a corner 20 of the I-shaped part fits exactly into a cutout 22 of the T-shaped part, a particularly good hold is always ensured, but tilting cannot lead to breakage of the material.

The entire integrator 2 is held together by means of shrink tubing 24.

A production method for an integrator shown in Fig. 2 and Fig. 3 is accordingly relatively simple. The individual parts 14 and 14' are manufactured, for example, by injection molding from plastic, from glass or the like and are given a

rimless reflective coating on the inner sides. Because of its high reflection factor, silver is particularly suitable as reflective coating. With reflection factors which should be substantially higher than 96%, however, a dielectric mirror layer should advisably be provided which can serve at the same time as a protective layer.

5                   The reflective coating is carried out in a substantially rimless manner, so that all surfaces of the parts 14 and 14' open to the inner side have a reflective coating with a high reflection factor when fitted one inside the other according to Fig. 3. After assembly, shrink tubing 24 is fitted over the parts. By treating with heat, this tubing shrinks and holds the parts 14 and 14' together with the greatest  
10                   possible stability, also due to the corner 20 which fits into the cutout 22. The elasticity of the shrink tubing enables simple assembly, particularly also with respect to the reduced risk of breakage when fastening when the parts 14, 14' are produced, as they usually are, from breakable material, particularly glass.

                  Fig. 4 shows an integrator similar to that shown in Fig. 2, but with  
15                   two slight modifications. First, instead of only one piece of shrink tubing 24, two pieces of shrink tubing 24' and 24'' are provided, which ensures better holding particularly at the ends. Second, a cutout 26 is made in the area of the input surface 12 in order to increase the compactness of a device constructed in practice according to Fig. 1. In the embodiment example, a screw head which would otherwise be  
20                   bothersome is accommodated in the cutout 26. The light losses of a cutout of this kind are correspondingly small when the angle attained by the in-coupling optics 10 is large enough for this cutout 26 to lie outside of the first reflection.

                  Further, it can be seen from Fig. 4 that shapes other than two T-shaped and two I-shaped parts 14, 14' are possible.

25                   In this respect, it must be stated that the invention can even also be realized when only two right-angled parts with corresponding cutouts are joined together. However, particular when manufacturing from glass, the arrangement of four parts is substantially more favorable because there are always plane surfaces which can be correspondingly precisely ground and polished.

30                   The preceding embodiment examples illustrated, above all, the simplicity of the construction and, therefore, a more economical method for

producing an integrator 2 of this kind. Further, the person skilled in the art will immediately discern some modification possibilities which lie within the scope of the invention. For example, two or three pieces of shrink tubing can also be used instead of a single piece of shrink tube 24. Moreover, the shaping of the parts 14 and 14' can be correspondingly modified, for example, by providing a tongue-in-groove connection between the parts.

Changes of this type are possible. However, the embodiment examples of Fig. 2 to Fig. 4 are particularly preferred, also because, among other reasons, a tongue-in-groove connection, for example, would increase the danger of breakage at the edges of the groove or the corners of the tongues when incorrectly inserted, for instance. The illustrated examples are also especially optimized for a simple and quick assembly of the parts 14 and 14' when manufacturing the integrator 2.

While the foregoing description and drawings represent the present invention, it will be obvious to those skilled in the art that various changes may be made therein without departing from the true spirit and scope of the present invention.

## Claims

1. Method for producing a light integrator (2), characterized by the following steps for forming a cavity of the integrator (2) having an inner reflective coating:
  - fabrication of at least two parts (14, 14') from which the light integrator (2) can be assembled and whose surfaces, provided as inner sides of the cavity, are exposed;
  - rimless reflective coating of at least the surfaces of the parts (14, 14') which are provided as inner sides of the cavity;
  - assembly and fastening of the parts (14, 14').
2. Method for producing a light integrator (2) according to claim 1, characterized in that fastening is carried out by means of the following steps:
  - covering the assembled parts (14, 14') with shrink tubing (24, 24', 24'');
  - shrinking the tubing until a suitable strength of the cavity integrator is achieved.
3. Light integrator (2) for homogenization of a light bundle entering an input surface (12) and exiting from an output surface (16), characterized in that it has a cavity with an inner reflective coating for conducting light, wherein the light integrator (2) is composed of at least two parts (14, 14') whose surfaces which are exposed prior to assembly and face inward after assembly are provided with a mirror layer.
4. Light integrator (2) according to claim 3, characterized in that one part is provided with a projection (20) engaging in a cutout (22) of the other part after assembly.
5. Light integrator (2) according to claim 4, characterized in that the inner sides and outer sides of the light integrator which form the cavity are planar, the light integrator (2) has the shape of a geometric prism with rectangular bottom and top surfaces provided as outlet and inlet surfaces (16, 12), and the projection and cutout (22) are rectangular, particularly square.

6. Light integrator (2) according to claim 5, characterized in that the light integrator comprises two T-shaped (14') and two I-shaped (14) side parts.

7. Light integrator (2) according to one of claims 1 to 6, characterized in that the parts (14, 14') are held together by means of at least one piece of shrink tubing (24).

8. Light integrator (2) according to claim 7, characterized in that shrink tubing (24) is arranged in the middle between the input surface (12) and output surface (16) for holding the parts (14, 14') together.

9. Light integrator (2) according to claim 7, characterized in that it has two pieces of shrink tubing (24', 24'') enclosing the light integrator for holding the parts (14, 14') together in the vicinity of their input surface and output surface (12, 16).

10. Use of the light integrator (2) according to one of claims 3 to 9 for homogenization of the light originating from a light source which is provided for the illumination of an electronically controllable matrix (4) for showing image elements.

11. Use according to claim 10, characterized in that the matrix (4) is a tilting mirror matrix.

## Abstract

A method for producing a light integrator (2) for forming a cavity of the integrator (2) having an inner reflective coating is characterized by the following steps:

- fabrication of at least two parts (14, 14') from which the light integrator can be assembled and whose surfaces, provided as inner sides of the cavity, are exposed;
- rimless reflective coating of at least the surfaces of the parts (14, 14') which are provided as inner sides of the cavity;
- assembly and fastening of the parts (14, 14').

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METHOD FOR PRODUCING A LIGHT INTEGRATOR, A LIGHT INTEGRATOR, AND  
A USE THEREOF

The invention is directed to a method for producing a light integrator and to a  
light integrator for homogenizing a light bundle entering an input surface and exiting from an  
output surface. The invention is further directed to a use of this method.

Light integrators are known. In principle, they comprise a body which is  
coated uniformly by reflecting material in which the light is introduced, the light is then  
repeatedly reflected back and forth at the reflecting surfaces. Because of the multiple  
reflection, the origin of the light for the light bundles exiting at the output is lost to a great  
extent. In this way, a homogenized illumination surface is achieved.

Integrators are used wherever especially uniform illumination is desired, for  
example, in imaging technology where every image component to be imaged should receive  
the same amount of light.

EP 0 734 183 A2 proposes a light tunnel which is inserted between  
illumination optics and an LCD matrix to be illuminated. This light tunnel, as it is called, is  
an elongated rectangular parallelepiped, for example, whose opposing surfaces on either side  
of a longitudinal axis determining the principal propagation direction of the light are utilized  
as light inlet and light outlet surfaces. The other surfaces at right angles to the principal  
propagation direction of the light are used as mirror surfaces.

Further, it is indicated in this reference that total reflection can also be utilized  
in that this rectangular parallelepiped is produced in a simple manner from one piece of  
smooth polished glass and the angles for coupling in are selected such that the reflection is  
carried out at the sides by total reflection.

Total reflection is extremely advantageous for these purposes because few  
losses need be taken into account. The only losses occurring in such light integrators in  
theory are caused by the absorption of the material; but this absorption can be suppressed to a  
very great extent when a glass of corresponding purity is used for producing an integrator of  
this kind.

However, holding a light tunnel or mixing rod of this kind presents  
difficulties. Every contact with the outside surface reduces and interferes with total  
reflection, so that there is a risk of corresponding losses due to scattering.

The principle of image generation such as it is presented in the European Patent, for example, is based on the light beams which are parallelized again after the light tunnel being directed to at least one LCD matrix. For image generation, the LCD matrix is controlled, for example, with a control device for showing video images. In principle, a video image could be projected into a screen as a large image with the technique known from slide projection or, as with the episcopes, could project the reflected light with LCD matrices with reverse reflective coating.

This large-image technique is looked upon as promising in terms of future developments because electronic picture tube technology cannot be used with very large images.

When using the reflected light projection method, a mirror matrix can be provided for image generation instead of the LCD matrix. A matrix of this kind is available, e.g., as a circuit, from Texas Instruments. In this circuit, a plurality of tilting mirrors, one for each image point, which are arranged in the form of a matrix is digitally controlled. In one of the digital states, every tilting mirror reflects the full light intensity; in the other state, the mirror receives and reflects the light at an angle at which it can no longer be projected onto the screen, i.e., the corresponding image point on the screen is dark with the exception of small proportions of scattered light.

The different brightness for showing a gray value or color value of a picture point can be brought about in that the mirrors are acted upon by pulse trains, so that only an intermediate value between the full light intensity and dark is detected in the eye of the observer for every image point averaged over time.

However, the large-projection method mentioned above imposes very strict requirements on the light integrator. That is, large light losses cannot be permitted in large-image projection if there is to be a sufficient quantity of light for an image projected onto a screen. As has already been made clear, only total reflection is suitable for this purpose, in principle; however, the support of a mixing rod presents difficulties because it can lead to excessive light losses. Further, the light inlet surface and outlet surface are exposed to a high energy flow of light and can accordingly change color. Further, dust on the inlet surface and/or outlet surface inevitably reduces the light flow in an uncontrolled manner. Because of these disadvantages, it would be extremely desirable to use other light integrators.



In order to prevent interference of reflection, as in total reflection, it is conceivable that all outer surfaces could be provided with a reflective coating in the rectangular parallelepiped-shaped rod mentioned above. However, this would result in the further disadvantage of cumulative light losses from the material and mirror.

5 In order to eliminate losses caused by material at least, it would be possible to guide the light inside a cavity with internal reflective coating. However, this idea can hardly be realized in optimal manner in practice because, as every person skilled in the art knows, a uniform internal reflective coating with sufficient mirror quality for minimizing losses cannot be realized in practice.

10 It is the object of the invention to provide an integrator which is optimized with respect to the amount of light that is transmitted, but which does not have the disadvantages of a totally reflecting rod.

This object is met by a method for producing a light integrator which has the following steps for forming a cavity of the integrator having an inner reflective coating:

- 15
- fabrication of at least two parts from which the light integrator can be assembled and whose surfaces, provided as inner sides of the cavity, are exposed;
  - rimless reflective coating of at least the surfaces of the parts which are provided as inner sides of the cavity;
  - assembly and fastening of the parts.

20 This results in a light integrator according to the invention for homogenization of a light bundle entering an input surface and exiting from an output surface, characterized in that it has a cavity with an inner reflective coating for conducting light, wherein the light integrator is composed of at least two parts whose surfaces which are exposed prior to assembly and face inward after assembly are provided with a reflective or mirror layer.

25 Accordingly, of the alternatives discussed above, the cavity with internal reflective coating is preferable. As was already explained above, this alternative would not have been reasonable at all and would not even have been considered by the person skilled in the art because an inner reflective coating with a permissibly low degree of losses would not have been possible at all. Prior to the invention, the only recourse would have been to  
30 provide a silver coating in the interior by vacuum deposition, for example; but this oxidizes easily when it is not provided with a protective layer. This protective layer would also cause absorption again.

In particular, it can easily be calculated that with a reflection factor of 96% and 5 reflections, 20% of the light in the integrator would be lost; and it is questionable whether such a high reflection factor could even be achieved. It is only by taking apart the cavity, according to the invention, that is, dividing the integrator into at least two parts, wherein the inner sides of the cavity are exposed with respect to the reflective coating, that it is possible to produce highly reflecting layers with a reflection factor of 98%, for example, by applying dielectric layers to the metal coating. With a reflection factor of 98%, which is certainly attainable in this way, a transmission of greater than 90% is provided with 5 reflections; that is, a loss of only 10% need be taken into account.

Further, it is possible to apply an essentially dielectric mirror possibly with a thin metal layer beneath it as back coat so as to further reduce losses.

The light propagates essentially in air in a cavity integrator, so that the losses are determined solely by the mirror layers and optionally low, permissible losses in the integrator can be achieved in accordance with expenditure. However, the assembly of the parts could cause additional losses, for example, due to glue at the glue joints. In particular, care should be taken that no glue accidentally falls on the mirror layers because this would result in proportionately high waste. Fastening the parts to one another with glue or by screw connection would also be time-consuming, which would add unnecessarily to the cost of producing an integrator of this kind if another possibility were not found.

According to a further development of the invention which is preferred in this respect, it is provided that the step for fastening is carried out by means of the following sub-steps:

- covering the assembled parts with shrink tubing;
- shrinking the tubing until a suitable strength of the cavity integrator is

achieved.

In this way, a light integrator according to the further development is characterized in that the parts are held together by means of at least one piece of shrink tubing.

The method of providing parts with shrink tubing is known from electrical engineering, wherein a piece of tubing which is larger than the location to be insulated, for example, a solder joint, is placed over the latter for fast insulation. By applying heat, for example, hot air, the tubing shrinks and completely encloses the solder joint, for example.

This method was previously provided exclusively for insulation and has proven to be a fast procedure for this purpose. It is used herein for the first time for fastening purposes.

This type of fastening is characterized by simple and fast handling. But also, due to the elasticity of the shrink tubing, the pressure is automatically distributed on the joined parts, which are preferably made from glass, and breakage or other damage to parts is prevented.

Further, due to its elastic tensioning, the shrink tubing ensures that the parts to be fastened are pressed very close together. With polishing grades commonly used in optics, this means that the parts can contact one another so as to be practically light-proof. Accordingly, there is only a slight chance that the light within the cavity could reach the area between contacting surfaces of the parts from which the light integrator is composed where it would no longer be available for illumination. This result could only be achieved in small measure with a glue and would also not be reproducible because the spacing of the parts would then be determined essentially by the amount of glue.

When production is carried out using glass and glue, positional tolerances of the opening of only  $+0.2$  mm can be achieved, whereas positional tolerances of less than  $0.05$  mm can be realized when fastening with plastic.

With respect to the fastening of the shrink tubing, two main alternatives are preferred:

1. Fastening by holding the parts together by means of shrink tubing arranged in the middle between the input surface and output surface;
2. Fastening by holding together the parts in the vicinity of their input surface and output surface by two pieces of shrink tubing enclosing the integrator.

The following further developments have to do essentially with the shaping of the parts in order to provide the most favorable possible integrator with respect to manufacture, economy and reproducibility. Preferred further developments of this kind are characterized in that:

- one part is provided with a projection engaging in a cutout of the other part after assembly;
- the inner sides and outer sides of the light integrator which form the cavity are planar, the light integrator has the shape of a geometric prism with rectangular

bottom and top surfaces provided as outlet and inlet surfaces, and the projection and cutout are rectangular, particularly square;

- the light integrator is composed of two T-shaped and two I-shaped side parts.

5 Above all, the projection in the cutout not only provides for a reproducible assembly, but also reduces a possible gap in which light could be lost, wherein the residual gap can be kept very small by means of pressing, for example, by means of the shrink tubing mentioned above.

10 The above-mentioned shaping with rectangular projection and cutout simplifies manufacture above all. In particular, the assembly of two T-shaped side parts and two I-shaped side parts simplifies the arrangement of the mirror layers. Further, there are only two sorts of parts, namely, T-shaped and I-shaped, which can then be produced in a simple manner by mass production. The embodiment examples shown in the following once again illustrate the most advantageous shaping of the individual parts.

15 Because of the low light loss, the use of such integrators for homogenization of the light coming from a light source provided for the illumination of an electronically controllable matrix for showing image elements is extremely advantageous. While the illumination of LCD matrices is already known from the prior art, it is also provided according to the invention that the matrix is a tilting mirror matrix when used in this way.

20 Further particulars of the invention are indicated in the following description of embodiment examples with reference to the accompanying drawings.

Fig. 1 is a schematic view illustrating the manner of operation of a light integrator using the example of projection with a matrix, particularly a tilting mirror matrix;

Fig. 2 shows a perspective view of an integrator according to the invention;

25 Fig. 3 shows a front view of the integrator of Fig. 2;

Fig. 4 shows another embodiment example for an integrator according to the invention.

The use of an integrator 2 for illuminating an LCD matrix or DMD matrix, referred to hereinafter as tilting mirror matrix, is illustrated schematically in Fig. 1. Its application is not restricted to matrices of this type for electronic image display; however, it is extremely advantageous to use an integrator of this type for illumination of such matrices, particularly because a tilting mirror matrix 4 has very small dimensions of less than 1mm\*1mm, a surface which cannot be illuminated uniformly when focusing with high luminous densities alone because the light spot usually has the same dimensions when focusing the light of a lamp with high luminous density.

The entire arrangement shown in Fig. 1 is arranged on one optical axis 6. This is also not limiting. An arrangement, e.g., optics, whose optical axes are offset relative to one another can also be put together.

A light beam 8, shown by way of example, which can be generated by means of a lamp provided with a parabolic mirror, is introduced into the input surface 12 of the integrator 2 through in-coupling optics 10. The light beam 8 is reflected back and forth repeatedly inside the integrator 2 which has a reflective coating on the inner side of the side parts 14 or when the integrator 2 comprises a medium with a suitable index of refraction for total reflection. This results in a pseudostochastic distribution of the entering light beams 8 in the light outlet surface 16.

Because of the pseudostochastic distribution, the light beam 8 is highly homogenized at the output of the integrator. It can be parallelized again by out-coupling optics 18 as is shown schematically in Fig. 1. The light bundle which is homogenized in this way is then directed onto the tilting mirror matrix 4 from which it is subsequently directed into projection optics which project the image that is generated electronically by the tilting mirrors of the tilting mirror matrix 4 onto a screen, thereby making it visible to the observer.

Fig. 2 shows an integrator 2, according to the invention, which is advantageous particularly for application with a tilting mirror matrix 4. The integrator 2 is a cavity integrator which has a reflective coating on the inner sides of the side parts 14, 14'. A cavity integrator is characterized above all by the fact that the inlet surface 12 and the outlet surface 16 are not thermally loaded, so that no changes in color occur with high light output and no dust particles can collect. An integrator 2 which is constructed as a cavity integrator is particularly advantageous when using small tilting mirror matrices because especially high luminous densities are used in this case.

In order to provide the cavity integrator with internal reflective coating in a simple manner, the cavity integrator is composed of four parts, two T-shaped parts 14' and two I-shaped parts 14. The arrangement and shape of the parts can also be seen particularly from Fig. 3. The T-shaped parts and I-shaped parts are shaped and pressed together in such a way that they do not allow any shearing movement relative to one another. The parts could also be shaped differently and put together with a cutout in the manner of tongue-in-groove so that an exact right-angled geometry is always ensured. However, due to the I-shaped parts 14 and the T-shaped parts 14' in which a corner 20 of the I-shaped part fits exactly into a cutout 22 of the T-shaped part, a particularly good hold is always ensured, but tilting cannot lead to breakage of the material.

The entire integrator 2 is held together by means of shrink tubing 24.

A production method for an integrator shown in Fig. 2 and Fig. 3 is accordingly relatively simple. The individual parts 14 and 14' are manufactured, for example, by injection molding from plastic, from glass or the like and are given a rimless reflective coating on the inner sides. Because of its high reflection factor, silver is particularly suitable as reflective coating. With reflection factors which should be substantially higher than 96%, however, a dielectric mirror layer should advisably be provided which can serve at the same time as a protective layer.

The reflective coating is carried out in a substantially rimless manner, so that all surfaces of the parts 14 and 14' open to the inner side have a reflective coating with a high reflection factor when fitted one inside the other according to Fig. 3. After assembly, shrink tubing 24 is fitted over the parts. By treating with heat, this tubing shrinks and holds the parts 14 and 14' together with the greatest possible stability, also due to the corner 20 which fits into the cutout 22. The elasticity of the shrink tubing enables simple assembly, particularly also with respect to the reduced risk of breakage when fastening when the parts 14, 14' are produced, as they usually are, from breakable material, particularly glass.

Fig. 4 shows an integrator similar to that shown in Fig. 2, but with two slight modifications. First, instead of only one piece of shrink tubing 24, two pieces of shrink tubing 24' and 24'' are provided, which ensures better holding particularly at the ends. Second, a cutout 26 is made in the area of the input surface 12 in order to increase the compactness of a device constructed in practice according to Fig. 1. In the embodiment example, a screw head which would otherwise be bothersome is accommodated in the cutout

26. The light losses of a cutout of this kind are correspondingly small when the angle attained by the in-coupling optics 10 is large enough for this cutout 26 to lie outside of the first reflection.

Further, it can be seen from Fig. 4 that shapes other than two T-shaped and two I-shaped parts 14, 14' are possible.

In this respect, it must be stated that the invention can even also be realized when only two right-angled parts with corresponding cutouts are joined together. However, particular when manufacturing from glass, the arrangement of four parts is substantially more favorable because there are always plane surfaces which can be correspondingly precisely ground and polished.

The preceding embodiment examples illustrated, above all, the simplicity of the construction and, therefore, a more economical method for producing an integrator 2 of this kind. Further, the person skilled in the art will immediately discern some modification possibilities which lie within the scope of the invention. For example, two or three pieces of shrink tubing can also be used instead of a single piece of shrink tube 24. Moreover, the shaping of the parts 14 and 14' can be correspondingly modified, for example, by providing a tongue-in-groove connection between the parts.

Changes of this type are possible. However, the embodiment examples of Fig. 2 to Fig. 4 are particularly preferred, also because, among other reasons, a tongue-in-groove connection, for example, would increase the danger of breakage at the edges of the groove or the corners of the tongues when incorrectly inserted, for instance. The illustrated examples are also especially optimized for a simple and quick assembly of the parts 14 and 14' when manufacturing the integrator 2.

## Claims

1. Method for producing a light integrator (2), characterized by the following steps for forming a cavity of the integrator (2) having an inner reflective coating:
  - fabrication of at least two parts (14, 14') from which the light integrator (2) can be assembled and whose surfaces, provided as inner sides of the cavity, are exposed;
  - rimless reflective coating of at least the surfaces of the parts (14, 14') which are provided as inner sides of the cavity;
  - assembly and fastening of the parts (14, 14').
2. Method for producing a light integrator (2) according to claim 1, characterized in that fastening is carried out by means of the following steps:
  - covering the assembled parts (14, 14') with shrink tubing (24, 24', 24'');
  - shrinking the tubing until a suitable strength of the cavity integrator is achieved.
3. Light integrator (2) for homogenization of a light bundle entering an input surface (12) and exiting from an output surface (16), characterized in that it has a cavity with an inner reflective coating for conducting light, wherein the light integrator (2) is composed of at least two parts (14, 14') whose surfaces which are exposed prior to assembly and face inward after assembly are provided with a mirror layer.
4. Light integrator (2) according to claim 3, characterized in that one part is provided with a projection (20) engaging in a cutout (22) of the other part after assembly.
5. Light integrator (2) according to claim 4, characterized in that the inner sides and outer sides of the light integrator which form the cavity are planar, the light integrator (2) has the shape of a geometric prism with rectangular bottom and top surfaces provided as outlet and inlet surfaces (16, 12), and the projection and cutout (22) are rectangular, particularly square.



6. Light integrator (2) according to claim 5, characterized in that the light integrator comprises two T-shaped (14') and two I-shaped (14) side parts.

7. Light integrator (2) according to one of claims 1 to 6, characterized in that the parts (14, 14') are held together by means of at least one piece of shrink tubing (24).

8. Light integrator (2) according to claim 7, characterized in that shrink tubing (24) is arranged in the middle between the input surface (12) and output surface (16) for holding the parts (14, 14') together.

9. Light integrator (2) according to claim 7, characterized in that it has two pieces of shrink tubing (24', 24'') enclosing the light integrator for holding the parts (14, 14') together in the vicinity of their input surface and output surface (12, 16).

10. Use of the light integrator (2) according to one of claims 3 to 9 for homogenization of the light originating from a light source which is provided for the illumination of an electronically controllable matrix (4) for showing image elements.

11. Use according to claim 10, characterized in that the matrix (4) is a tilting mirror matrix.

## Abstract

A method for producing a light integrator (2) for forming a cavity of the integrator (2) having an inner reflective coating is characterized by the following steps:

- fabrication of at least two parts (14, 14') from which the light integrator can be assembled and whose surfaces, provided as inner sides of the cavity, are exposed;
- rimless reflective coating of at least the surfaces of the parts (14, 14') which are provided as inner sides of the cavity;
- assembly and fastening of the parts (14, 14').

1/1

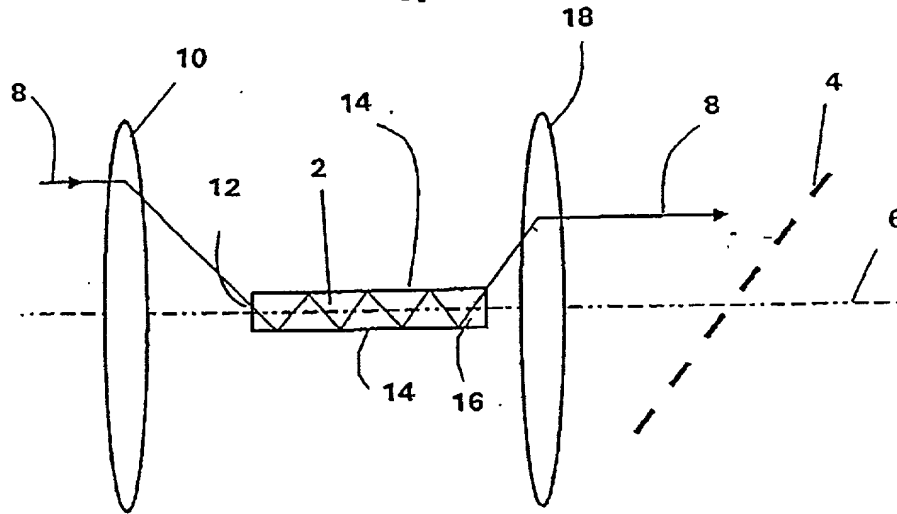


Fig. 1

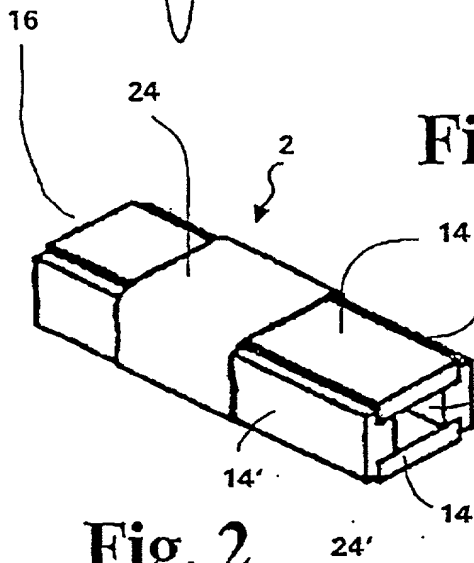


Fig. 2

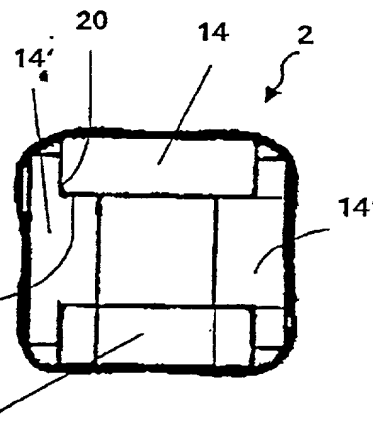


Fig. 3

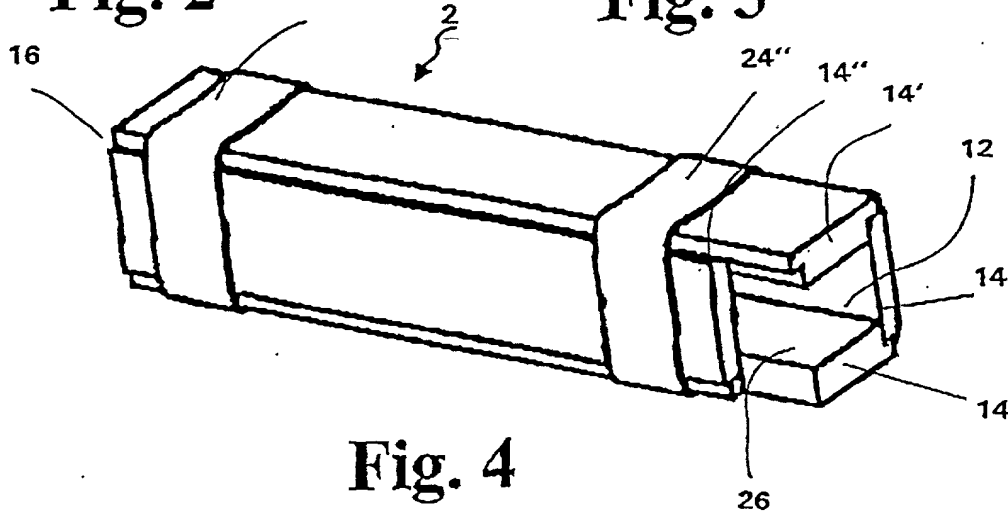


Fig. 4

UNITED STATES OF AMERICA  
COMBINED DECLARATION AND POWER OF ATTORNEY  
FOR PATENT APPLICATION

FILE NO. GK-GEY-1112/  
500350.20135

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that I verily believe that I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD FOR PRODUCING A LIGHT INTEGRATOR, A LIGHT INTEGRATOR, AND A USE THEREOF

The specification of which

- ☐ is attached hereto.  
☐ was filed on \_\_\_\_\_ as United States patent application Serial Number \_\_\_\_\_.  
☒ was filed on August 18, 2000 as PCT international patent application No. PCT/EP00/08090 and was amended on \_\_\_\_\_ (if any).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information known to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. 119
Germany	199 40 305.8	25 August 1999	YES <u>X</u> NO ____
			YES ____ NO ____

I hereby appoint REED SMITH LLP and the members of the firm: Lloyd McAulay, Reg. No. 20,423; J. Harold Nissen, Reg. No. 17,283; Jules E. Goldberg, Reg. No. 24,408; Gerald H. Kiel, Reg. No. 25,116; Eugene LeDonne, Reg. No. 35,930; Stephen Chin, Reg. No. 39,938; Arthur Dresner, Reg. No. 24,403; Daniel Lent, Reg. No. 44,867; and Samir R. Patel, Reg. No. 44,998 as attorneys with full power of substitution and revocation to prosecute all business in the Patent & Trademark Office connected therewith and to receive all correspondence.

SEND CORRESPONDENCE TO: Gerald H. Kiel, Esq.  
REED SMITH, LLP  
375 Park Avenue  
New York, New York 10152-1799, U.S.A.

DIRECT TELEPHONE CALLS TO: (212) 521-5400

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

FULL NAME OF SOLE OR FIRST INVENTOR Peter DANNENBERG		INVENTOR'S SIGNATURE <i>Peter Dannenberg</i>	DATE 30.04.2001
RESIDENCE CH-8106 Adlikon-Regensdorf, Switzerland CHX		COUNTRY OF CITIZENSHIP Germany	
POST OFFICE ADDRESS Hummelackerstr. 29, CH-8106 Adlikon-Regensdorf, Switzerland			
FULL NAME OF SECOND INVENTOR (IF ANY) Bernhard WAGNER		INVENTOR'S SIGNATURE <i>Bernhard Wagner</i>	DATE 9.04.2001
RESIDENCE D-07768 Kahla, Germany CHX		COUNTRY OF CITIZENSHIP Germany	
POST OFFICE ADDRESS Ross-Strasse 32, D-07768 Kahla, Germany			